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STUDENTS' PERCEPTIONS OF A PROBLEM-BASED LEARNING ENVIRONMENT

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ABSTRACT. During the last decades, traditional learning environments have been criticised for not developing the prerequisites for professional expertise (H. Mandl, H. Gruber & A. Renkl, *Interactive minds: Life-span perspectives on the social foundation of cognition,* pp. 394–412, Cambridge, UK: Cambridge University Press, 1996; P. Tynjälä, *International Journal of Educational Research*, *31*, 357–442, 1999). To meet this criticism, educational approaches such as problem-based learning, project-based learning and case-based learning are being implemented to an increasing extent. Research also concentrates on the efficiency of these approaches in terms of students' learning outcomes. At the same time, classroom-based theories of learning (J. B. Biggs, *British Journal of Educational Psychology*, *63*, 3–19, 1993; M. Prosser & K. Trigwell, *Understanding learning and teaching.* Buckingham, UK: SRHE and Open University Press, 1999) stress the importance of the investigation of subjective learning environments in order to understand the nature of these students' learning outcomes, for learning results are not a mere function of the learning setting because each student operates as a filter for the possible influence of the environment. However, most research on students' perception of the learning environment is conducted in predominantly traditional learning environments.

The goal of our research was to investigate students' perceptions of the key design variables of a problem-based learning environment and if students perceive that they enhance learning. There are four research questions. First, to what extent do students' perceptions of a PBL environment match the theoretical assumptions of PBL? Second, do their perceptions differ as a function of the institutional context? Third, is there a difference in the perceptions of students between groups of first year and experienced students and between disciplines? Fourth, are there interaction effects between study phase and discipline?

The results show that, in general, students value the key variables of the learning environment as powerful (i.e. enhancing learning). Also, the results indicate that students' perceptions of the learning environment in various institutional contexts differ significantly. In general, no distinctions were found related to students in different study phases. However, in terms of specific design variables, students studying in diverse disciplines showed significantly divergent perceptions. Finally, significant interaction effects were found between study phase and discipline.

KEY WORDS: learning environment, problem-based learning, students' perceptions

1. Introduction

Societal, economic and technological changes are transforming professional life. Being a professional nowadays includes knowing how to deal with increasing internationalisation, knowing how to use information technology, being communicative, working in a team or network, and mastering the required expertise (Harvey, 1993; Harvey, Burrows & Green, 1993; Tynjälä, 1999). This increase in requirements for professionals not only influences employee training programs but also the expectations formulated for higher education. Many well-known experts in the field of learning and instruction (e.g. De Corte, 1990; Pellegrino, Chudowsky & Glaser, 2001) have been stressing that it is generally agreed that acquiring thinking and problem-solving skills is a primary objective of education. Allan (1996) as well as Bowden and Marton (1998) confirm this by describing the aims of higher education in terms of desired learning outcomes such as subject-based, personal transferable and generic academic outcomes. The information community of tomorrow expects from graduates that they have a certain knowledge-base but also the skills to solve problems, analyse, synthesise, coach, lead, present and evaluate.

However, educational practices have been criticised for not developing these prerequisites of professional expertise. Research results (Mandl, Gruber & Renkl, 1996) indicate the problem that students often acquire inert knowledge in traditional forms of instruction. Students have the knowledge but they cannot use it to solve complex problems of daily working life. As Tynjälä (1999) points out, the important challenge for today's higher education is the development and the implementation of instructional practices that integrate domain-specific knowledge with the personal-transferable and generic academic skills. In this respect, many attempts have been made to develop instructional models alongside the traditional knowledge transmission models. Most of them are based on a constructivist view of learning and have led to the development and implementation of so-called 'powerful learning environments' (De Corte, 1990).

2. Powerful Learning Environments

'Powerful learning environments' have the purpose to develop an educational setting where the students' learning is the core issue and instruction is defined as learning-enhancing. These learning environments go together with the constructivist conception of learning and its pedagogical applications. Prawat (1996) describes the core idea of constructivism as follows: "Learning is a process of active construction. That process results in a qualitative change in understanding" (p. 48). The acquisition of knowledge can also be described as "a building process in which knowledge is actively constructed by individuals or social communities" (Tynjälä, 1999, p. 364). Students are not passive recipients of information, but they actively construct their knowledge and skills through interaction with the environment, and through reorganisation of their own mental structures.

The pedagogical implications of this constructivist conception leads to the defining features of powerful learning environments:

1. Learning is more important than instruction.
2. Teaching is no longer the transmission of knowledge, but is rather supporting students to actively construct knowledge by assigning them tasks that enhance this process (Tynjälä, 1999).
3. Learners' previous knowledge, beliefs and conceptions are significant because learners construct new knowledge on the basis of their existing knowledge (Dochy, 1992).
4. Co-operative learning includes the need for emphasis on negotiation and sharing of meanings through discussion and different forms of collaboration (De Corte, 1996; Gregen, 1995; Spiro, Feltovich, Jacobson & Coulson, 1995).
5. Authentic problems are the starting point of the learning process.
6. Learning is contextualised. Knowledge is partly the result of the specific activity, the context and the culture in which that knowledge is acquired (De Corte, 1996).
7. Assessment is not a separate activity, exclusively performed at the end of the course; assessment procedures have to be integrated in the learning process itself (Segers, 1996; Tynjälä, 1999). Assessment should focus on authentic tasks and take into account learners' individual orientations and foster their metacognitive skills (Dochy & Moerkerke, 1997; Segers, Dochy & Cascallar, 2003).

These characteristics, to an important extent, are congruent with the features of new educational approaches in a range of disciplines, such as problem-based learning (PBL), case-based learning, project-based learning, etc. These educational approaches encompass a curriculum that intends to incorporate the pedagogical implications of constructivism. They are designed to create a powerful learning environment. This study presents the case of a problem-based learning environment. The learning environment variables designed to scaffold student learning are described in the next section.

3. Designing Powerful Learning Environments: The Case of PBL

Various researchers have described the characteristics of PBL environments (e.g. Barrows & Tamblyn, 1980; Boud & Feletti, 1997; Van den Bossche, Gijbels & Dochy, 2000). They are closely related to the key features of powerful learning environments. PBL can be defined as follows (Barrows, 1986; Van den Bossche et al., 2000):

1. The learning process is student centred: the students construct actively and cooperatively their knowledge base, on the basis of learning goals that they formulate themselves. Therefore, the learning in a PBL environment is defined as self-directed.
2. It occurs in small student groups: collaborative learning with sharing and negotiating information and knowledge is the main activity.
3. The tutor (teacher) is the facilitator of the learning process: the tutor does not have the role of transmitter of knowledge. She/he stimulates the group discussions and monitors the social group processes.
4. The problem tasks are the starting point for learning, a query or a puzzle that the learner wishes to solve (Boud, 1987): students address authentic problems, building upon their prior knowledge in order to achieve the required knowledge as well as the problem-solving skills. The problems are used as a tool to identify the required knowledge to eventually solve the problem.

The problem-solving process, central within a PBL environment, is guided by a framework through which students learn to systematically explore and analyse problems. This framework is schematised in Table I, describing the seven main steps that the students take when working together on a problem. Steps 1–5, as well as step 7 and the time-out step, are collaborative activities with a focus on sharing and negotiating information and knowledge. Step 6 is an individual activity. For each step, Table I indicates the objective of the step and the expected learning outcomes. They refer explicitly to characteristics of powerful learning environments: (1) to the active knowledge construction process of students (all seven steps); (2) the important role given to prior knowledge (Steps 1 and 2) and (3) the focus on formative assessment, stimulating reflection on the problem-solving process and products as a tool for learning (Steps 5, 7 and the time-out step).

In summary, the characteristics of PBL are strongly reflected in the defining features of a powerful learning environment. It is therefore not surprisingly that De Corte (1990), as well as Segers, Dochy and De Corte (1999), draw the conclusion that "the design of the PBL instructional process resembles to a large extent the characteristics of a powerful learning environment" (Segers et al., 1999, p. 194).

On the basis of the design variables of PBL as determined by Gijselaers (1988), we can identify three sources of important input variables: the student; the problem(s) (or problem-tasks) used; and the tutor. All of these features have an effect on what happens, both in the tutorial groups and outside the group sessions. The process that leads to solving the problem primarily takes place during the group sessions (group process) and during

TABLE I

Learning Process of a Problem-Based Curriculum, Objectives and Learning Outcomes

Steps of the problem-solving process	Objectives	Learning outcomes
1. Reading the problem and clarifying terms and concepts if necessary	Students have to deal with a real-life problem belonging to the subject matter in the field in which they wish to be competent.	Acquiring knowledge in the context of the subject matter leads to better understanding, remembering and application of the knowledge.
		Tasks stimulate learning if they are relevant for the learning goals.
2. Defining the problem	Students observe and try to describe the subject of their observation.	Learning is an ongoing process of insight in new structures and in relating them to the knowledge already acquired.
	Students are stimulated to use their prior knowledge (and experiences) and to transferring it to a new situation.	The network of concepts extends, refines and becomes more complex.
3. Analysing the problem	Students practise in dealing with problems in a logical, analytical and scientific manner.	Continuously practising in analysing problems in a variety of situations promotes effective learning.
4. Inventory		
5. Formulating learning goals	Students are encouraged to reflect on the subject matter that they are discussing even though they lack understanding. They experience this as a challenge to learn and not as a disgrace.	Students are owners of their learning process by formulating their own learning goals. This has a positive effect on the student outcomes.
		Cognitive conflict is a stimulus for learning.
		Reflection on the learning process promotes effective learning.

(*Continued on next page*)

TABLE I
(*Continued*)

Steps of the problem-solving process	Objectives	Learning outcomes
		Students experience permanent learning as a challenge. This is an important condition for the development of a professional competence.
6. Self-study activities	Students work independently to solve the formulated learning goals (problems). Students search for relevant information and transform the information in accordance to the problem-solving process.	Students are responsible for their learning process.
7. Synthesis and evaluation of the acquired knowledge	Students exchange their experience in searching and transforming the information. Students discuss, compare and clarify the relevance of the discovered information in regard to the initial and related problem(s).	Learning occurs in a social context. Feedback is a condition for effective learning. Transfer of knowledge is practised through application in a realistic context.
→ Time-out: Evaluation moments	Feedback is provided on the content of the subject matter, the learning process and the group process.	Reflection on the experience of learning contributes to effective learning.

the self-study time of the individual students. There are two output variables of the learning process: the learning results of the student and the extent to which the student is more or less interested in the study and more or less motivated to study. The present study focuses on the input and process variables.

3.1. *The Use of Problems for Learning*

Gijselaers and Schmidt (1990) found that problem features have a great overall influence on process (e.g. group work, time spent on self-study) and outcome variables (achievement and motivation). This seems logical, if one sees the central role of problems in the PBL approach (Gijselaers, 1995):

- Problems are used to create a gap between existing prior knowledge and knowledge required to manage the problem adequately, and consequently guide the self-study (Dochy, Segers & Buehl, 1999).
- Problems are used to increase students' motivation in respect to the subject matter of the domain, particularly because the information is called for in the same way as in the real situation.
- Problems are used to enhance group work.
- Problems cover theoretical and practical issues reflecting the core of education for the profession.
- Often there is not one solution but many solutions to the problem task. The solution sometimes depends on the perspective chosen during the problem analysis.

3.2. *The Tutor*

While working on a problem, the group is guided by a tutor. The tutor has two main functions. Firstly, the tutor is a stimulator of the learning process. She/he will stimulate the students to reflect more deeply on the represented content. Secondly, the tutor is a stimulator of the collaboration process. For this purpose, she/he must be skilled in managing small-group tutorials. The tutor monitors and evaluates the extent to which each group member contributes to the group's task and tries to create the conditions in which each group member can function optimally. The tutor makes a flexible adaptation of the instructional support possible, taking into account individual differences among learners in cognitive aptitudes as well as in affective and motivational characteristics (De Corte, 2000).

3.3. *The Student*

PBL asks for an active learning attitude. PBL fosters independent study behaviour. The students are given a greater responsibility for their own learning process (Boud & Feletti, 1997) in that

- students are responsible for searching their study materials;
- students have to decide if the material is relevant;
- students have to search for a study path;
- students have to ask fellow-students or tutors for extra information if they do not grasp something.

3.4. *The Tutorial Group*

One of the central characteristics of the PBL approach is the small tutorial group. The activities in the tutorial group are determined by seven successive steps (see above). The small group makes it possible for students to complement each other in this problem-solving process and provides a means to 'scaffold' the learning process of the student. Woods (1994) describes the advantages of working in small groups as follows: learners get actively involved; learners work co-operatively; it allows for individual preferences; it motivates students to use their time productively; it provides feedback on student performance; it empowers learners to have a role in the assessment process; it fosters frequent and rich tutor-student interaction; it supports developing problem-solving skills, group skills and other processing skills. To sum up, the tutorial group provides an environment for attaining active, co-operative learning with informal feedback.

3.5. *Self-Study Activities*

Students search, read and study the information required in accordance to the learning goals which they formulated. During the tutorial group session, they discuss, compare and clarify the relevance of the discovered information in regard to the initial problem. As well as becoming skilled in finding the acquired information resources, self-directed learning allows students to become aware of their own personal learning needs (Barrows, 1986). They take an active role in determining the learning goals, how to reach them, how to study them, how to plan the time needed to acquire the knowledge and skills, and how to evaluate what they have learned (Albanese & Mitchell, 1993).

4. Students' Perceptions of Their Learning Environment

In the context of powerful learning environments, and more specific problem-based learning environments, students' conceptions of learning and knowledge are often challenged because the ways in which they are expected to be creators of knowledge seldom have been experienced before. These environments can be a significant challenge to students who expect learning to be transmission of knowledge. It appears from research into students' learning that students today construe learning tasks as predominantly assimilating and reproducing material supplied by academics rather than engaging in what tends to be a meaningful and framing experience for themselves (Barnett, 1997). Although it might be expected that powerful, and more specific problem-based learning environments, enhance students' learning, these personal theories-in-use, as conceptualised by Schön (1983), might cause a barrier for learning because of the student's personal resistance towards change. In this respect, Snyder (1971), amongst others, was of influence in bringing the term 'hidden curriculum' to the attention of the higher education community. In other words 'what teachers and learners actually do on the ground' is a kind of de facto curriculum. The hidden curriculum is not a given fact, it is constructed by the students, through their interpretations, perceptions and actions (Sambell & McDowell, 1998). Students interpret instructional interventions (Entwistle & Tait, 1990). It is not the instructional setting itself, but rather the interpretation of the environment that triggers the learner to engage in particular learning activities and to reach an effect (Anderson, 1989; Doyle, 1977). Boud (1995), for example, emphasises the influence of prior and other educational experiences in this construction and interpretation process: "Students are not simply responding to the given subject, they carry with them the totality of their experiences of learning and being assessed" (p. 87).

In this respect, Biggs (1978), as well as Prosser and Trigwell (1999), have proposed a model for understanding learning and teaching in higher education (see Figure 1).

In this model in Figure 1, students' perceptions of the learning and teaching context are seen to be an interaction between their previous experiences of learning and teaching and the learning and teaching context itself. They approach their studies in relation to their perceptions of the context and this in turn is related to the quality of their learning outcomes. The perspective adopted is that students do not act upon the objective world, or the learning environment as designed, but on the world 'as they experience it'. This experienced world is a result of the internal processing of the objective information of the learning and teaching context as students receive it, such as the goals of the course, the assessment, the working procedures, etc. This implies that, although the context could be designed to afford a particular

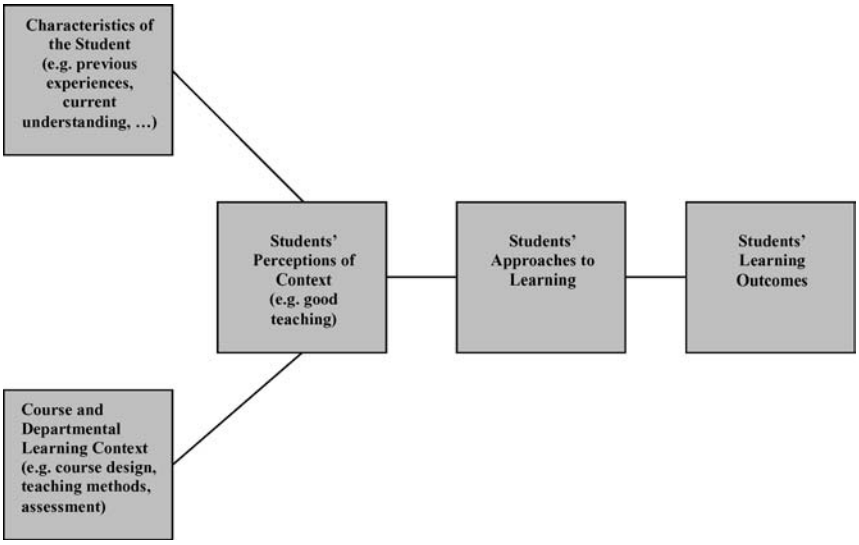

Figure 1. A model of student learning (Prosser & Trigwell, 1999).

approach to study, the students do not necessarily perceive the situation in the 'intended way' and therefore could act differently than expected or 'designed'. Thus, given the same objective context, different students form different perceptions of their situation and, as a consequence, they tend to approach their learning tasks in different ways. These variations in perceptions are influenced by students' prior experiences.

Former research in various disciplines have confirmed the importance of students' perceptions of their learning situation (Crawford, Gordon, Nicholas & Prosser, 1994; Jackson & Prosser, 1989; Lizzio, Wilson & Simons, 2002; Struyven, Dochy & Janssens, 2003; Trigwell, Hazel & Prosser, 1996) and how they might be manifested as resistance to the instructional format (Thorn, Vigilante & Silverthorn, 2002).

However, these studies are conducted within more traditional educational contexts. Within the context of powerful learning environments, and more specifically problem-based learning, not much research has focused on the students' perception of the learning environment. Most studies report students' evaluations of PBL courses, focusing on students' satisfaction with various design variables. They are based on surveys asking students if the goals are clear, the problems are authentic, the learning materials are well-structured, etc. However, the key question is to what extent students perceive these design variables as enhancing their learning. Only a few studies address explicitly the students' perception of the extent to which PBL is powerful for enhancing learning. Pereira, Telang and Butler (1993) describe the common failing with PBL programs due to entrenched, non-constructivist models of learning of the students. The change to PBL represents to the students a disruption to their existing assumptions, which then result in resistance. Also O'Hanlon, Winefield, Hejka and Chur-Hansen (1995) refer to the transitional problems associated with moving to a group-based learning environment, especially where former academic performances were obtained through individual success on a competitive basis. They report students' evaluations of a first-year medical program run in parallel PBL and traditional modes, and note that, although students were highly motivated by the PBL approach, overall the traditional approach was favoured as being more beneficial. Many students were undecided. Sim Heng Chye, Wee Keng Neo and Da Silva (2000) report the experiences of the Temasek Business School in Singapore where PBL was introduced in the final third year. Many of the students were already accustomed to the traditional lecture-based teaching. When they asked students if they thought that PBL was an effective way of learning and teaching, only 37% agreed (with 34% disagreeing). Only 32% of the students found PBL interesting. They concluded that students' responses were more a reaction to a new method of learning and indicated resistance to change, rather than ineffectiveness of PBL.

These research studies indicate that students' perceptions of PBL as promoting learning do not match the expectations of its designers. However, these studies address the students' perceptions on a more general level, and not at the level of the key variables of the PBL environment. Additionally, although these studies discuss the relevance of the students' prior experiences with teaching and learning for the observed perceptions, there is hardly any evidence of the influence of the educational context in which the PBL environment is situated, and whether there is an effect of students' prior experiences with PBL. Finally, most studies have been conducted in medical education. There is no comparative research on students' perceptions in other disciplines.

5. Research

5.1. *Research Goal*

The purpose of the investigation was to find out whether students' perceptions of the learning environment coincide with the intended powerful problem-based learning environment. In other words, is there a match between the various aspects of the learning environment as perceived by the students and what is meant to happen? Four related questions are explored. First, to what extent is there a match between students' perceptions of various aspects (key design variables) of the PBL situation and the learning that is meant to occur through these aspects? Second, to what extent are there differences in students' perceptions between students experiencing PBL during a course within a more traditional (lecture-based) curricula and students studying in a PBL curriculum? Third, to what extent are there differences between first-year students with no or little experiences with PBL and final-year students who already experienced PBL for 2 years and more? Fourth, to what extent are there differences between various disciplines and how does this interact with the students' study phase?

5.2. *Instrument*

In order to assess how students perceive their learning environment, a questionnaire was developed. The questionnaire was constructed on the basis of the design variables of the PBL curriculum as described above. In order to develop a valid instrument, the Delphi methodology was used. Six experts, educational scientists working with PBL in various disciplines for many years, discussed the relevance of the items. As a result of this negotiation on the relevance of the items, a total of 46 items was reduced to 31 items, because there was an overall consensus about the quality of this set among all experts in the Delphi panel.

The survey consisted of items in four scales assessing the students' perceptions of the role of (1) the Tutor, (2) the Tutorial Group and (3) the Problem Task to enhance learning, as well as (4) the kinds of student activities enhanced by problem-based learning (Student scale). In addition, the students were asked in general which aspects (Tutor, Tutorial Group, Problem Task) promote the acquisition of knowledge. The items were scored on a 5-point Likert scale. In Table II, one sample item is presented for each scale.

Furthermore, the instrument contained five open-ended questions that gave students the possibility to elaborate on the main characteristics of their learning environment. Two examples of this type of question were "Which problems did you encounter while working according to the problem-based learning model?" and "What is the most important characteristic (of PBL) according to your experience with the model?"

The aim of the survey was explained to the students by the researchers, especially that it was not intended to evaluate the PBL course(s) that they had followed recently. It was explained to them that PBL is introduced in curricula because it is hypothesised that it will enhance student learning. The survey aims to explore to what extent students who experienced PBL perceive the different characteristics of PBL as effective for their learning.

Evidence for the reliability of the instrument was found by computing the internal consistency (Cronbach's alpha coefficient) for the data for the whole sample and for the scales (Thorndike, 1988). Moreover, there was

TABLE II
Examples of Questions in the Students' Perceptions Questionnaire

Scale	Sample question
In general	To what extent do the following features of PBL enhance the acquisition of knowledge: the tutor, the tutorial group, and the working on problems?
Tutor	Which tutor skills are supporting the functioning of the tutorial group: stimulating critical reflection on information and ideas brought into the group by peer students?
Tutorial group	Being present in the tutorial group is necessary to master the learning goals.
Problem task	Problem tasks stimulate discussion and critical reflection in the tutorial group.
Student	The problem-based design of the course requires students to actively and critically reflect on your own thinking and that of your peers.

a check if there were any items that caused a lowering of the homogeneity of scales. Subsequently, the reliability of the scale, when the item with the lowest Rit was deleted, was calculated. If items did lower the homogeneity, these items were removed from the questionnaire (Baarda & de Goede, 1997).

The Cronbach's alpha coefficient of 0.88 indicated a high overall reliability of the questionnaire (the closed questions part). When the questionnaire was divided into scales, the alpha coefficients stayed high in most cases, taking into consideration the minimal length of the scales: 0.79 for the Tutor scale; 0.73 for the Tutorial Group scale; 0.70 for the Student scale; and 0.70 for the Problem Task scale. If the homogeneity of the scales was computed after deleting the item with the lowest Rit at the scale level, the alpha coefficient did not change significantly.

The questions under the heading 'In General' measure the perceived effect on learning of three design variables. They are not supposed to be homogeneous and therefore they are not interpreted as a scale.

5.3. *Subjects*

The survey was administered to a group of 240 university students from three different learning environments. In Leuven ($n = 17$) and Leiden ($n = 27$), all of the students in the training program were asked to fill out the questionnaire. In Maastricht, because of the large populations and for feasibility reasons, random samples of students were taken ($n = 196$). The sample included freshmen (6 weeks), students in their first year, and more experienced students in their third or fourth year.

The three different learning environments investigated in this study were based on the problem-based learning model as it has been developed at the Maastricht University. However, the three different learning environments in the institutional contexts differed in the setting in which PBL was implemented. At the University of Leuven, a 1-year course was provided according to the Maastricht PBL model within a more traditional educational sciences curriculum (ES) (5-year training). At the University of Leiden, one module of 6 weeks was provided to fourth-year students according to the Maastricht PBL model, also in a more lecture-based educational sciences curriculum. While at the University of Maastricht, in order to investigate discipline effects, the research was conducted within two schools. Students in the School of Economics and Business Administration (EC) and in the School of Law were following a 4-year curriculum designed according to the PBL model.

In summary, students were divided among the different learning environments in the following way:

1. University of Leuven: 27 ES students, 1-year PBL course in a 5-year traditional curriculum;
2. University of Leiden: 17 ES students, 6-week PBL module in a 4-year traditional curriculum;
3. University of Maastricht: a 4-year PBL curriculum with:

   - 50 EC students, first-year students, after 6 weeks of experience with PBL;
   - 52 EC students, third- or fourth-year students;
   - 49 law students, first-year students after 6 weeks of experience with PBL;
   - 45 law students, third- or fourth-year students.

In the Leuven and the Leiden case, the tutors have worked with the Maastricht PBL model for many years and implemented it in their courses in Leuven and Leiden. Therefore, the factual design of the courses in the three cases can be seen as highly comparable.

5.4. *Method of Analysis*

Firstly, in order to find out which of the three design variables (Tutor, Tutorial Group, Problem Task) discriminate between the groups of students in the three different learning environments, we used a stepwise multiple discriminant analysis. Analysis of variance (ANOVA) was used to compare the means at the scale level, followed by a Bonferroni analysis, to identify where the differences between the different populations lie.

Secondly, the analysis was directed to the third learning environment, with a totally problem-based curriculum. The influences of the study phase of the educational programme (the first-year group versus the experienced students' group) and the discipline (law versus economics) were investigated. A stepwise multiple discriminant analysis was conducted to discriminate between the students of the two study phases and the two disciplines on the basis of the three PBL design variables. A two-tailed *t*-test was conducted twice to compare the means at the scale level. Next, a two-way ANOVA analysis was employed to search for interactions between the phase of the educational programme and the discipline at the scale level.

Finally, the qualitative answers on the open questions by the students were quantified by categorising them. The categories were defined by carefully reading all the answers in relation to the research questions. A tentative and interpretative reading of the data in the categories is reported.

6. Results

6.1. *Learning Environments*

We compared the answers of the students on the questionnaire for the three different types of learning environments as implemented in the institutional contexts: the Leuven, the Leiden and the Maastricht group.

Firstly, at the level of the three design variables of PBL, of Tutor, Tutorial Group and Problem Task, the results of a stepwise multiple discriminant analysis indicated that the design variables Problem Task ($F[2,\ 235] = 6.17$, $p < 0.005$) and Tutor ($F[4,\ 468] = 5.88$, $p < 0.001$) were discriminating between the three learning environments. The variable Problem Task explained 52.5% of the variance and the variable Tutor explained 47.7% of the variance. The Leiden students ($m = 4.41$) perceived working with problem tasks as more important for enhancing learning than the Leuven group ($m = 4.22$) and the Maastricht students ($m = 3.82$). The tutor was perceived as of less importance for enhancing the acquisition of knowledge by the Leuven students ($m = 3.27$), in comparison with the Maastricht ($m = 3.76$) and Leiden ($m = 4.23$) students.

Secondly, at the scale level, analyses of variance were conducted to compare the means of the three learning environments. Table III presents the mean scores (and standard deviations) aggregated at the scale level: Tutor, Tutorial Group, Problem Task and Student. Differences must be significant at the 0.05 level.

The ANOVA results showed significant F values for all scales (Tutor, Tutorial Group, Problem Task, Student) regardless of the differences between the learning environment (Leiden, Leuven, Maastricht).

TABLE III
Mean Scores at the Scale Level for the Three Different Types of Learning Environment

	Learning environment									
	Leuven		Leiden		Maastricht				Overall	
Scale	Mean	*SD*	Mean	*SD*	Mean	*SD*	*F*	*p*	Mean	*SD*
In general	3.79	0.46	4.25	0.67	3.81	0.56	5.06	0.007	3.84	0.56
Tutor	3.02	0.58	3.92	0.56	3.59	0.58	15.20	0.000	3.55	0.61
Tutorial group	3.85	0.46	4.23	0.47	3.76	0.58	5.64	0.004	3.80	0.57
Problem task	3.96	0.38	4.37	0.40	3.67	0.64	12.15	0.000	3.75	0.63
Student	4.22	0.50	4.40	0.42	4.00	0.55	5.87	0.003	4.05	0.61

A post hoc Bonferroni analysis showed that the significant difference occurred between the Leiden and Maastricht group: the Leiden group scored higher than the Maastricht group, with the Leuven group scoring in between the other groups. Except in the cases of the Tutor scale, the Leuven group underscored both the Leiden ($p < 0.000$) and Maastricht ($p < 0.000$) groups.

Overall, when the mean scores are compared, the Student scale scored highest ($m = 4.05$) and the Tutor scale scored lowest ($m = 3.55$). Looking at the overall means of the items revealed that the lower score on the latter scale was especially due to the low score on the item that is worded: "The tutor facilitates and supports the interpersonal relations in the group" ($m = 2.82$).

A stepwise multiple regression analysis provided information about the contribution of each item to the scale score. All items had a significant contribution to the total scale score ($p < 0.000$). The size of the standardised beta coefficients, when the model contained all of the items of the scale, did not differ. The values were in the interval 0.22–0.35 for the Tutor scale, 0.22–0.26 for the Tutorial Group scale, 0.29–0.37 for the Problem Task scale, and 0.22–0.32 for the Student scale.

6.2. *Phases of the Educational Programme*

In order to explore the effect of prior experiences, we compared, within the same setting for the 4-year PBL curriculum in Maastricht, first-year students with more-experienced students (third and fourth years), for the School of Economics and Business Administration as well as for the School of Law.

First, at the level of the three design variables of Tutor, Tutorial Group and Problem Task, the results of a stepwise multiple discriminant analysis indicated that the design variable Problem Task was discriminating

TABLE IV
Mean Scores for the Two Phases of the Educational Programme

	Phase					
	First-year group		Graduate group			
Scale	Mean	*SD*	Mean	*SD*	*t*	*p* (two-tailed)
In general	3.87	0.57	3.75	0.54	1.57	0.117
Tutor	3.61	0.65	3.58	0.49	0.39	0.697
Tutorial group	3.80	0.58	3.71	0.58	1.17	0.244
Problem task	3.77	0.56	3.58	0.70	2.07	0.040
Student	4.04	0.55	3.95	0.56	1.18	0.238

between the first-year group ($m = 3.98$) and the graduate group ($m = 3.67$) ($F[1, 193] = 5.39$, $p < 0.05$), although the differences in mean scores between both groups were small.

Table IV shows the means (and standard deviations) for the two phases of the educational programme: the first-year group and the experienced-students group. A two-tailed *t*-test for equality of means showed that there were no differences between the two phases. There was only a slight significant difference ($p = 0.04$) concerning the variable Problem Task, with students in the first-year group considering this variable as more critical for their learning.

6.3. *Disciplines*

Besides the effects of prior experiences, we looked for discipline effects, controlling for educational context. A comparison was made between both schools of the University of Maastricht. At the level of the three design variables of Tutor, Tutorial Group and Problem Task, the results of a stepwise multiple discriminant analysis indicated that the design variable Problem Task was discriminating between the School of Law ($m = 4.04$) and the School of Economics and Business Administration ($m = 3.63$) ($F[1, 193] = 10.07$, $p < 0.005$). Table V presents a comparison between two disciplines, including descriptive statistics (mean, standard deviation) for each group for the scales.

A *t*-test for equality of means showed that the groups differed significantly concerning the answers on the scale Tutorial Group ($p = 0.018$) and slightly significant on the scale Problem Task ($p = 0.047$). The law students regarded these as being more enhancing to learning.

TABLE V
Mean Scores for the Two Disciplines

	Discipline					
	Law		Economics			
Scale	Mean	*SD*	Mean	*SD*	*t*	*p* (two-tailed)
In general	3.90	0.54	3.73	0.56	2.21	0.029
Tutor	3.55	0.65	3.63	0.50	−0.94	0.349
Tutorial group	3.86	0.59	3.66	0.56	2.35	0.018
Problem task	3.77	0.57	3.59	0.69	2.00	0.047
Student	4.05	0.50	3.95	0.60	1.18	0.239

TABLE VI
Interaction Effects between Phase of the Educational Program and the Discipline

	Law				Economics					
	First-year group		Graduate group		First-year group		Graduate group			
Dependent variable	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	*F*	*p*
In general	3.84	0.08	3.97	0.08	3.91	0.08	3.56	0.08	9.64	0.002
Tutor scale	3.45	0.08	3.66	0.09	3.76	0.08	3.51	0.09	7.71	0.006
Tutorial group scale	3.86	0.08	3.85	0.09	3.75	0.08	3.57	0.09	1.05	0.307
Problem task scale	3.87	0.09	3.66	0.09	3.67	0.09	3.50	0.09	0.06	0.814
Student scale	4.10	0.08	3.99	0.08	3.99	0.08	3.91	0.08	0.02	0.885

6.4. *Phase of the Educational Programme × Discipline Interaction*

We checked for interactions between study phase and discipline. Table VI shows that there was a significant interaction effect between study phase and discipline for the Tutor scale ($p = 0.006$). This was twice a disordinal interaction. The group of third- and fourth-year students in the School of Law scored the highest twice while, within the economics groups, the first-year group scored highest twice.

6.5. *Open Questions*

In this section, the results of the categorisation of the open-ended questions will be presented. The percentage of the students who mentioned a certain subject is reported in every case. In general, students mentioned all of the main characteristics of PBL as important aspects of the learning environment (Barrows, 1986; Van den Bossche et al., 2000). Most frequently mentioned design variables are the Tutorial Group (50%) and the activity of the Student (31.8%). Less frequently mentioned is the Problem Task (15.1%). Very few students saw the tutor as the central person in the learning environment (4.1%). Appreciation by the students of the various design variables (e.g. "What do you appreciate by working according to the PBL model?") of the PBL environment was strongly equivalent (the Tutorial Group 39%, the Student 45%, the Problem Task 18% and the Tutor 3.6%).

Looking at the indicated problems, the following picture emerged: 28% of the students indicated having problems with the social aspects of working in little groups. Also several problems were mentioned with respect to the activity of the students: uncertainty (13.9%), the time aspect (16.8%), and self-activities and self-study (25.2%). The Problem Task was not mentioned as causing problems. On the contrary, some students (12.8%) saw the tutor as a source of problems.

Looking at the different phases of the curriculum (first-year students versus experienced students), the experienced students indicated less problems with the activity than the first-year students. This suggests that a period of getting used to the way of working in a PBL environment was necessary for students to be able to cope with it. However, the social aspect of the learning groups and the tutor were more frequently mentioned as problematic in the third and fourth years than in the first-year phase.

7. Discussion

In general, it can be concluded that students value the various aspects of the problem-based learning environments as enhancing learning. In this respect, there is a match between the students' perceptions and what is meant to happen.

The mean scores on almost all statements are close to or higher than four (on a 5-point scale). This means that students perceive most statements, which are a translation of the 'powerful' characteristics of PBL, as being of high consequence for their learning.

Overall, the Tutor scale is lowest and the Student scale is most highly perceived as enhancing learning. Results suggest that students rate an expert tutor as more effective than a less content-expert tutor. Albanese and Mitchell (1993) attribute these outcomes as follows: "While tutors with subject matter expertise tend to be less facilitative, they appear to better enable students to identify relevant learning issues and correct gaps in knowledge and errors in processing" (p. 75). Students tend to have a preference for a tutor with a directive style because of their belief that it gives them more certainty about the subject matter to be studied for the examination. Laurillard (1997) comments that students take a rational approach to learning: "Students consider what is required of them, they decide on priorities, and they act accordingly. The teacher plays an important part in forming their perceptions of what is required and what is important, and it is this, as much as their style of presenting the subject matter, which influences what and how their students learn" (p. 144). Because of the facilitative role of the tutors in PBL instead of a directive role, probably the students perceive them as less contributing to their learning, in comparison with the other design variables.

Highly encouraging is the finding that the Student scale is perceived as highly contributing to students' learning. This indicates that the purpose of the powerful learning environment is achieved, namely, promoting students as active learners, who show independent study behaviour and responsibility for their own learning process. This is in line with Charlin, Mann and Hansen (1998) who use four principles as a basis for the analysis of the value of PBL activities: learners are active processors of information; prior knowledge is activated and new knowledge is built upon it; knowledge is acquired in a meaningful context; learners have opportunities for elaboration and organisation of knowledge.

All the beta coefficients derived from the stepwise multiple regression analysis of the items on the scales were significant and of the same size. This indicates that the students value the different operationalisations of each design variable of PBL as powerful for learning.

Is there an influence of the context in the way that students perceive the different aspects of problem-based learning? There was a clear influence of what was called the type of learning environment (Dochy, Segers, Van den Bossche & Gijbels, 2003; Van den Bossche, Segers, Gijbels & Dochy, 2001). Overall, the design variables of the PBL environment were seen as of less importance for learning in the Maastricht group. This is probably due to the fact that the point of reference of the Leiden and Leuven group is the traditional educational system with an overload of lectures. Research of Tynjälä (1999) indicated that the most significant differences between the groups (traditional students and students in constructivist learning environments) appeared in the students' subjective description of their own learning. Next to their description of learning in terms of knowledge acquisition, most constructivist group students used terms such as "gaining an ability to apply knowledge, the development of their critical thinking skills, changing their conceptions of the topics studied and having a more relativistic view on knowledge" (p. 411). Students of a traditional educational system did not use those descriptions as frequently. Probably because of the clear contrast between the students' conceptions of learning (by experience more in terms of knowledge acquisition) and the learning aimed for in PBL, these students perceive the PBL design variables as of more importance for their learning than do the Maastricht students experiencing only PBL. This effect might have been reinforced by the fact that the Leiden and Leuven students had already studied Educational Sciences for many years and were acquainted with recent insights in learning and instruction.

The aforementioned generally lower recognition of the role of the tutor is particularly clear in the Leuven group. Especially on the item "The tutor guides the discussion in the tutorial group", the Leuven group scored significantly lower than the other groups. This can be explained by the difference in implementation of the role of the tutor. In Leuven, they make use of a so-called 'flying tutor'. This neologism points to the fact that the tutor is not always present in the tutorial group and changes all the time between two or three tutorial groups. This explains why the students do not experience the tutor as 'guiding the discussions in the tutorial group'. Remarkably, the students do not see this as damaging to his/her task as stimulator of the learning process: the Leuven group does not score lower on the statements belonging to this task. This way of organising PBL, mostly for reasons of shortage of manpower, has a detrimental effect on the task of the tutor to stimulate the collaboration process; the students see the tutor as having no effect on this side (certainly compared with the other learning environments). From the point of view of the faculty management, it could be questioned if the system of 'flying tutor' should be taken into consideration in the first year of a problem-based curriculum. Students have to activate prior knowledge towards a subject matter that is experienced as 'new' and within an educational system that they are not used to.

Small differences are found between the different educational phases and disciplines within the context of a complete problem-based curriculum. This is an indication that the most important external factor influencing the perception of PBL is the broader instructional context in which it is implemented. Neither the educational phase nor the discipline has a high influence on the perceptions of the students (Van den Bossche et al., 2000). However, the results indicate interaction effects: the graduate law students and the first-year Economics students perceive the tutor as highly contributing to their learning. This might be explained by the difference in the type of knowledge that students have to acquire. The knowledge base that law students in their first year of study have to acquire has a more declarative and propositional nature than the knowledge base of first-year students in Economics and Business Administration. In the latter case, for many problems discussed, various theories and models and the conditions for them to be appropriate, rather than a specific act, are relevant. However, when moving towards the third- and fourth-year program, law students discuss more complex cases and, depending on the perspective, various acts could be relevant. In the case of problems with various relevant perspectives and solutions, guidance by a tutor could be perceived as being more supporting for learning.

The answers to the open-ended questions confirm the conclusion drawn by the analysis of the clusters: students do value the different aspects of a PBL environment. Concerning the problems experienced with the PBL student activities, the results indicate that, although students perceive the tutorial group as effective for their learning, they need time to get acquainted and to feel comfortable about working in such a student-oriented learning environment. For education, this might imply that supporting students with more guidance and feedback on their cooperative learning, as well as self-regulated learning, can be seen as an important role for the teacher in this process. On the other hand, gaining more experience in PBL makes students more demanding with respect to the social aspects of learning in PBL and the tutor. Probably, by being more experienced, they gradually have higher expectations and demands.

To conclude, in comparison with the few previous research studies, the present research brings a more optimistic message. In general, students studying in a mainly traditional learning environment perceive the various design variables of PBL as enhancing their learning. Probably because of the contrast with their models of learning (O'Hanlon et al., 1995; Pereira et al., 1993; Sim Heng Chye et al., 2000), students in Leiden and Leuven need more explicit support in their learning involving the various PBL design variables. Therefore, they more clearly perceive the importance of the design variables for their learning. However, the fact that the Leiden and Leuven students are Educational Sciences students might have influenced the results. Probably because of the attention paid to theories of learning and instruction and their intrinsic motivation in learning and teaching processes, these students might be more open for powerful learning environments than students in other disciplines. In short, the contrast with their models of learning might have led to a need for more support instead of resistance to change. For other disciplines, this implies that, when students have insight into the rationale of PBL and the principles of learning and instruction underpinning PBL, this might enhance students' acceptance of PBL and therefore optimise the learning effects. Nevertheless, we do agree with Kwan's (2000) observation as a consultant in many medical schools in the Asia Pacific region: "Students are young and flexible enough to learn to be tolerant and adaptable to new ways of learning. It is a common observation that persistent resistance, despite the evidence of many successful examples, comes largely from teachers" (p. 2).

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